A White Paper from the Experts in Business-Critical Continuity™

# *Longevity of Key Components in Uninterruptible Power Systems*

EMERSON™
Network Power

## Executive Summary

Every UPS is designed with components that have a limited life. Some of these components have longer lives than others and this depends on the design of the component itself, its function within the UPS, and the operating conditions to which the UPS is subjected to.

In this white paper, we briefly discuss the functional life of key components and the frequency at which Liebert suggests their replacement. Even though these key components have a limited design life, a well planned preventive maintenance service on the UPS, that includes the periodic replacement of these components, may ensure a continuous and reliable operation of the UPS for many years to come.

## Introduction

A Liebert UPS has a design life well in excess of 10 years. Well-maintained units can continue to provide economic benefits for 20 years or more. Long-life components are used in a UPS whenever it is practical and cost-effective. However, due to current component material and manufacturing technology limitations, a few components in a Liebert UPS will wear out and require replacement in less than 10 years.

In order to prevent a wear-out failure of one of these components affecting the critical load operations, it is recommended these components be periodically inspected and replaced before they reach their expected wear-out life.

The reliability of any system only lasts as long as the shortest component life in the unit.

## Magnetics: Transformers, Inductors, DC Chokes

The design value of most magnetic components is 40 years of operation. Key factors here are the insulation used in the winding process and the temperature rise while in service. Our magnetics use Class H insulation rated at 220°C, and are never operated at higher than 150°C.

Some commutation inductors (used in SCR-based UPS modules) may exhibit deterioration after ten to fifteen years of service due to load variations and the constant cycling of the current through the inductor. Before it fails, the inductor starts to vibrate and becomes very noisy. This condition will be obvious during preventive maintenance, and the Customer Engineer can schedule a return visit to replace the inductor. Experience has shown that with proper preventive maintenance, no definitive replacement interval is needed to preclude inadvertent UPS shutdown.

## Power Semiconductors

Power semiconductors do not have a rated end of life in the normal mode of operation of the UPS. SCR or IGBT failures are generally secondary symptoms of other problems.

During the annual preventive maintenance cycle, semiconductor devices should be visually inspected for corrosion and for damage to the hermetic seal. If corrosion or seal damage is found, the device should be replaced. In addition, gate leads should be inspected and mounting torque of the semiconductor hardware checked. We do not recommend changing the power semiconductors in a large UPS at regular intervals.

## Electrolytic DC Capacitors

The expected life of electrolytic capacitors can be calculated as a function of manufacturer's rating and the expected operating temperature of the device. Please refer to Appendix A: Design Life Calculations for Electrolytic Capacitors. The theoretical service life of DC capacitors ranges from 8 years to 30 years, depending on system bus voltage and UPS ambient temperature.

Experience proves that capacitors should be replaced significantly before the end of their rated service life. This helps account for variations in ambient temperature, air-borne contaminants and other environmental factors.

Emerson Network Power recommends replacing DC capacitors every six to seven years.

Table 1 shows Theoretical Life at various ambient temperatures. Refer to Appendix A for the formula used to arrive at these figures.

## Oil-Filled AC Capacitors

The oil-filled capacitors have a design life of ten years, and a replacement life of seven years. As oil-filled capacitors approach their design life, they are subject to the internal breakdown of the soggy foils and possible loss of capacitance. We recommend that all oil-filled capacitors be inspected and those within six months of their replacement life (seven years) can be changed out during the annual preventive maintenance (PM) cycle. The oil-filled capacitors should also be inspected during the annual PM for deformation, which indicates that the capacitor needs replacing. Changing the AC oil-filled capacitors based on service life is generally not part of most maintenance contracts, but can be included.

## Circuit Boards

There is no rated service life on the components specified for use on the circuit boards. Circuit boards with problems are removed and returned to the manufacturing plant for repair and test. Before they are returned to service, they will have all outstanding revisions incorporated and will then be system tested. If a circuit board returns a second time for the same problem, it is scrapped. All calibrations are verified during annual PM to ensure that the circuit boards don't exhibit signs of failure. If weakness is found during the PM, the circuit board will be replaced.

| DC Bus Voltage | Ambient Temp °C | Theoretical Life Hours | Theoretical Life Years |
|---|---|---|---|
| 405 | 20 | 279,351 | 31.9 |
| 405 | 25 | 197,531 | 22.5 |
| 405 | 30 | 139,675 | 15.9 |
| 405 | 35 | 98,765 | 11.3 |
| 405 | 40 | 69,838 | 8.0 |
| 540 | 20 | 293,318 | 33.5 |
| 540 | 25 | 207,407 | 23.7 |
| 540 | 30 | 146,659 | 16.7 |
| 540 | 35 | 103,703 | 11.8 |
| 540 | 40 | 73,329 | 8.4 |

**Table 1**

The most serious limitation to circuit board longevity is availability of replacement components for some boards. Certain parts are no longer available from manufacturers. Emerson Network Power has safety stock on some key components, but it's difficult to foresee all contingencies. Please note that this parts-availability issue affects all vendors of both static and rotary UPS products.

## Limited Life Components

As mentioned previously, every UPS is designed with components that have a limited design life. A UPS's functional life is effected by its working conditions. The typical limited life components found in a UPS are listed on the following page in Table 2, as well as the design life and the time at which Liebert Services recommends replacement.

Generally, power capacitors are considered "failed" when the measured capacitance is 5% below the nameplate rating. Typically, storage batteries are "worn out" when its full load reserve time is 20% below rated. Site-specific battery plants may have different end-of-life requirements. Fans and blowers typically will stop rotating or rotate slower than expected.

In most cases, replacement components must match exactly the original component specifications. Many are not readily available from 3rd party component distributors. For assistance with your specific component specifications, replacement component selection and sourcing, call 1-800-Liebert (1-800-543-2378).

For customers using Liebert Services Preventive Maintenance, periodic inspection of these components are part of this service as is a recommendation of replacement intervals to avoid surprise interruptions in critical load operations.

## Conclusion

All UPSs are designed and manufactured with components that have limited life. The reliability and continuous operation of a UPS can significantly be improved over the years by properly maintaining it. This preventive maintenance must include a periodic system inspection and replacement of key components that by design have a limited life. Some of these components may last longer than others, but the reliability of the system can be compromised by the component with the shortest design life. Therefore, Liebert Services strongly recommends that any UPS system be periodically inspected and key components be replaced to ensure optimum support to the customer's critical load.

| Component | Expected Life | Replace In |
|---|---|---|
| Power AC filter capacitors | >7 years (~62,000 hrs) | 5-6 yrs |
| Power DC filter capacitors | >7 years (~62,000 hrs) | 5-6 yrs |
| Low-profile fans | >7 years (~62,000 hrs) | 5-6 yrs |
| Squirrel-cage blowers | >10 years (~87,600 hrs) | 8-9 yrs |
| Air filters, disposable | 1 to 3 years | Check 4 times/yr |
| Battery, lithium, logic memory backup | 10 years | 8-9 yrs |
| Battery, storage, lead-acid wet-cell | 10 to 20 years | 1-2 yrs prior to end-of-life |
| Battery, storage, valve-regulated lead-acid | 5 year battery | 3-4 yrs |
| Battery, storage, valve-regulated lead-acid | 10 year battery | 6-8 yrs |

**Table 2**

## Appendix A

**Design Life Calculations for Electrolytic Capacitors.**

The expected life of these capacitors has been confirmed to follow Arrhenius' equation – a formula describing chemical reactions due to dielectric molecules activated by thermal energy. We can calculate **L**, expected device life in hours, according to the following:

**$L = L_{BASE} \times 2^{((T_{BASE} - T_{CORE})/10)} \times$ Voltage Multiplier**

***where:***

| | | |
|---|---|---|
| $L_{BASE}$ | = | 5,000 hours at 85°C core temperature and rated voltage |
| $T_{BASE}$ | = | 85°C |
| $T_{AMB}$ | = | 30°C |
| $T_{CORE}$ | = | $T_{AMB} + T_{RISE-AVG}$ = 30°C + 10°C = 40°C |
| $V_R$ | = | Rated Voltage |
| $V_A$ | = | Actual Voltage |
| Voltage Multiplied = (2.50 – 1.5) $V_R/V_A$ | | |
| | = | 700/540 = 1.2963 for 540 volts DC bus (480 VDC nominal) |
| | = | 500/405 = 1.23 for 405 volts DC bus (360 VDC nominal) |

Solving this we get:

| | | |
|---|---|---|
| L | = | 5,000 x 2^((85-40)/10) x 1.2963 |
| | = | 5,000 x 2^4.5 x 1.2963 |
| | = | 146,659 hours (16.7 years) for a 540 volts DC bus and 30°C |
| | | |
| | = | 5,000 x 2^((85-40)/10) x 1.23 |
| | = | 5,000 x 2^4.5 x 1.23 |
| | = | 139,158 hours (15.9 years) for a 405 volts DC bus and 30°C |

Substituting 40°C for UPS ambient temperature we obtain:

| |
|---|
| 73,329 hours (8.4 years) at 540 VDC and 40°C |
| 69,838 hours (8.0 years) at 405 VDC and 40°C |

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